

V5 Level 2 Product Levels, Layers and Trapezoids

# AIRS/AMSU/HSB Version 5 Level 2 Product Levels, Layers and Trapezoids

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## V5 Level 2 Product Levels, Layers and Trapezoids

### A Discussion of the AIRS Level 2 Products Levels, Layers and Trapezoids and Top of Atmosphere and the Surface in Product Profiles

#### *Introduction*

In this documentation, names in bold are fields in the AIRS product files.

Please note in the discussion which follows, non-profiles are swath data fields dimensioned (**GeoXTrack**[30 elements], **GeoTrack**[45 elements]). The level quantity profiles of the Standard Product are dimensioned (**StdPressureLev**[28], **GeoXTrack**[30], **GeoTrack**[45]) and the layer quantity profiles are dimensioned (**StdPressureLay**[28], **GeoXTrack**[30], **GeoTrack**[45]). On the other hand, the level quantity profiles of the Support Product are dimensioned (**XtraPressureLev**[100], **GeoXTrack**[30], **GeoTrack**[45]) and the layer quantity profiles are dimensioned (**XtraPressureLay**[100], **GeoXTrack**[30], **GeoTrack**[45]).

#### *Pressure Grids, Surface Pressure and Bottom Element of Profiles*

The surface pressure, **PSurfStd**, is derived from the NCEP GFS 3-, 6- and 9-hour forecasts of surface pressure and the topography provided by a digital elevation model (DEM):

$$\mathbf{PSurfStd} = \mathbf{P_F} \times \left[ 1 - \frac{(\mathbf{h} - \mathbf{h_F})}{\mathbf{c_p T_s}} \mathbf{g} \right]^{7/2}$$

where **P<sub>F</sub>** is the forecast surface pressure; **h** is the altitude from the DEM; **h<sub>F</sub>** is the forecast altitude; **T<sub>s</sub>** is the forecast surface temperature; **c<sub>p</sub>** is the gas constant; **g** is the gravitational constant. The forecast surface pressure is interpolated to the AMSU FOV centroid, and the elevation is the average over the DEM within the AMSU FOV.

The fixed pressure grid for the AIRS Level 2 Standard Temperature Product, **pressStd**, contains 28 levels defined congruent with the World Meteorological Organization (WMO) standard pressure levels. Thus the highest pressure in the array is the first element. The 17 WMO standard pressures are a subset of this pressure array. The level spacing is closer together in the lower atmosphere. The units are mb. See **V5\_L2\_Standard\_Pressure\_Levels.pdf** for a table of the pressure level array, **pressStd**.

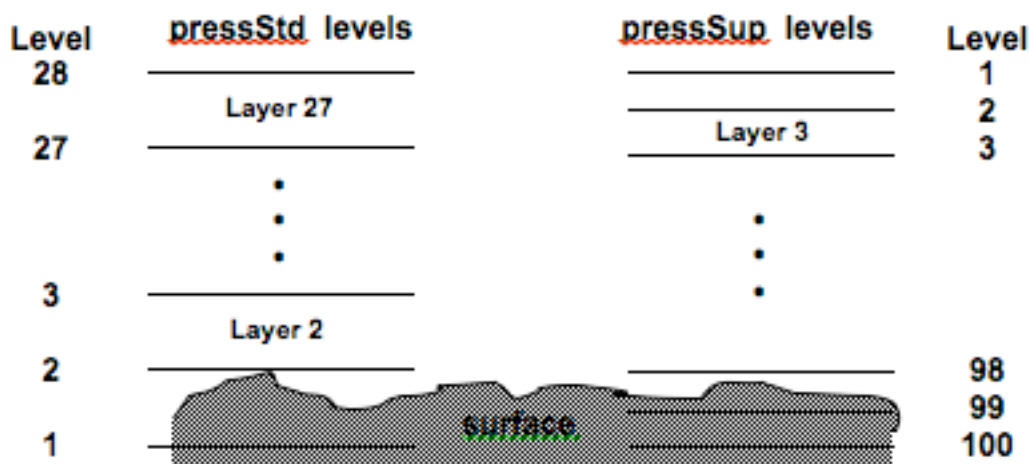
The standard product profiles are filled, decrementing indices from the top of atmosphere (TOA), array element 28, to the near-surface array element at (1-based) index **nSurfStd**. This bottom level is below the surface topography unless the pressure

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at the surface is within 5 mb of the pressure of the next **pressStd** level upward. In that case, **nSurfStd** is the index of that level and is above the surface. Entries in standard product profiles whose indices are less than this index must be ignored. They are customarily set to -9999.

The fixed pressure grid for the AIRS Level 2 Support Product, **pressSupp**, contains 100 levels, and is the pressure grid used by the AIRS rapid transmittance algorithm (RTA) to calculate radiances. The order of pressures is reversed from that of **pressStd**, i.e. the first pressure is at the TOA. The order and finer grid were defined to facilitate diagnosis of the retrieval process and calculation of radiances from the retrieved physical products. Thus the highest pressure in the array is the last element. The level spacing is closer together in the lower atmosphere. The units are mb. See **V5\_L2\_Support\_Pressure\_Levels.pdf** for a table of the pressure level array, **pressSupp**.

The support product profiles are filled, incrementing indices from the TOA, array element 1, to the near-surface array element at (1-based) index **nSurfSup**. This bottom level is below the surface topography unless the pressure at the surface is within 5 mb of the pressure of the next **pressSupp** level upward. In that case, **nSurfSup** is the index of that level and is above the surface. Entries in support product profiles whose indices are greater than this index must be ignored. They are customarily set to diagnostic intermediary values during the retrieval process, and are not physically meaningful.



**Figure 1: Layout of pressStd and pressSupp levels.**

If the surface topography is within 5 mb of **pressStd** level index 2, then **nSurfStd** = 2; otherwise **nSurfStd** = 1 in this example.

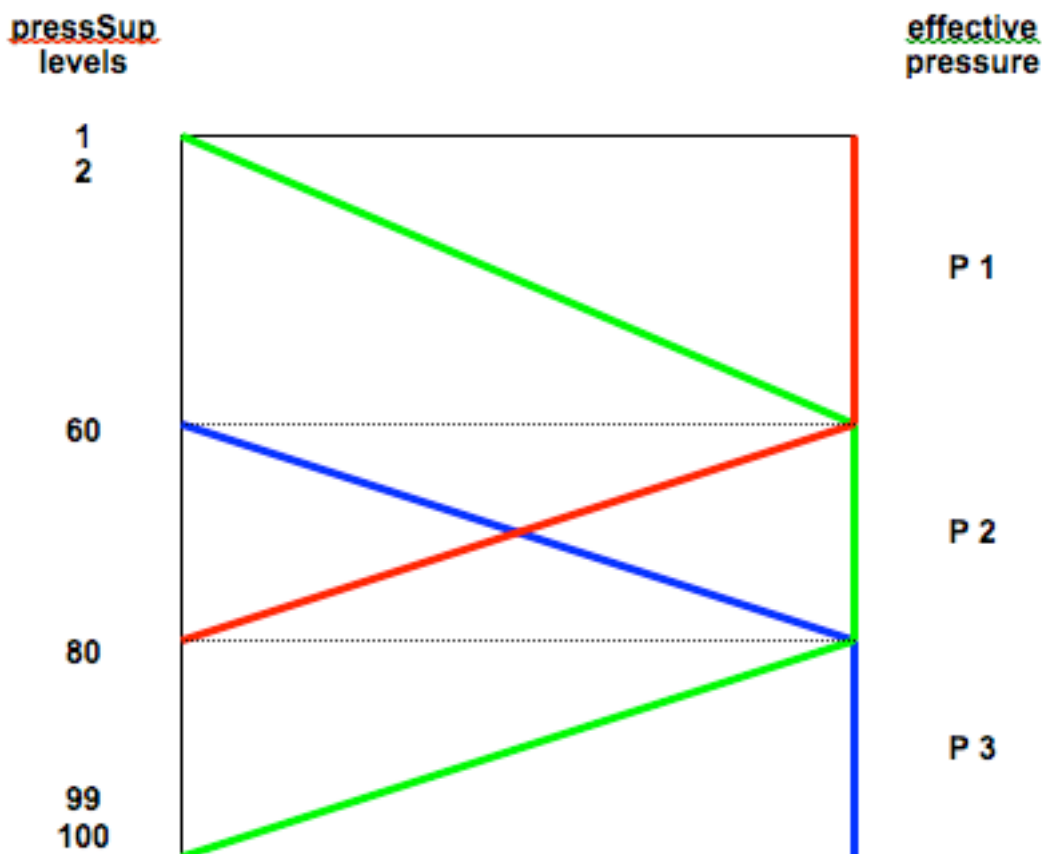
Similarly, if the surface topography is within 5 mb of **pressSupp** level index 98, then **nSurfSup** = 98; otherwise **nSurfSup** = 99 in this example.

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A table of the pressure values for the **pressStd** array is provided in **V5\_L2\_Standard\_Pressure\_Levels.pdf**. A table of the pressure values for the **pressSupp** array is provided in **V5\_L2\_Support\_Pressure\_Levels.pdf**.

### *Trapezoidal Layers*

A new concept, trapezoidal layers, is introduced in V5 to support associated averaging kernels, verticality and degrees of freedom of retrieved constituents. They define the bounds upon which the IR retrieved layer quantity mixing ratios of CO, CH<sub>4</sub> and O<sub>3</sub> are defined which are associated with the kernels, verticality and degrees of freedom.



**Figure 2: Schematic of a three-trapezoid profile for constituent XX.**

The trapezoids are defined by the array, **XX\_trapezoid\_layers**, which contains the 1-based indices of the **pressSupp** profile containing the relevant pressures. The effective pressures of the trapezoidal layers, **XX\_eff\_press**, are given in millibar. Thus in this example for constituent XX, **XX\_trapezoid\_layers** = [1,60,80] and **XX\_eff\_press** = [P 1, P 2, P3]. The constituent volume mixing ratio, **XX\_VMR\_eff**, is also a 3-element array. The bottom trapezoid face is always terminated at the surface.

The number of trapezoids depends upon the constituent being retrieved. The sides of the trapezoids drop off from the face linearly in log(p), dropping to zero at the pressure

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level of the most distant vertex of the adjacent trapezoid face. The lowest altitude trapezoid drop off terminates at the surface and the highest altitude trapezoid drop off terminates at the top of the atmosphere. **XX\_VMR\_eff** is computed from the integrated column density for each trapezoidal layer, and is reported at the effective pressure, **XX\_eff\_press**, of the layer. **XX\_eff\_press** is defined as the pressure weighted center of the layer. Layers below the surface are filled with -9999. The value quoted on the lowest layer above the surface is the mean volume mixing ratio in the layer bounded by the next higher level and the surface.

**XX\_total\_column** is the integrated column amount of XX from the top of the support product atmosphere (0.005 mb) to the surface. It is computed by summing the 100 column density values, **XXCDsup**, contained in the AIRS Level 2 Support Product file, with the appropriate weighting applied to the bottom layer that contains the surface. Layers below the surface are not included in the sum.

**XX\_dof** provides a measure of the amount of information in the constituent retrieval. It is computed by summing the diagonal elements of the averaging kernel, **XX\_avg\_kern**, stored in the AIRS Support Product files. Profiles for which **XX\_dof** < 0.4 indicates little information in the retrieval comes from the measured radiances. Profiles for which  $0.5 > \mathbf{XX\_dof} > 0.4$  should be used with great caution.

**XX\_verticality** is a vector computed by summing the rows of **XX\_avg\_kern**. Our code sums the columns since the AIRS averaging kernel is symmetric. The peak of **XX\_verticality** indicates the vertical location of the maximum sensitivity of the constituent product and the magnitudes of **XX\_verticality** are a rough measure of the fraction of the retrieval determined from the data as opposed to the first guess. Values near unity should be considered highly determined from the measurement, while smaller values indicate the retrieval contains a large fraction of the first guess. Verticality values are sometimes less than zero, especially for the lowest and highest trapezoids.

The problem with associating the verticality with a total column averaging kernel is that it neglects the fact that the retrieval can only move as superpositions of the trapezoids. Convolution using the verticality alone will not account for the possibility that the “independent constituent profile” contains structure that the trapezoids can or cannot resolve. Bearing this caution in mind, a researcher convolving an independent profile to the AIRS measurement space must perform the calculation:

$$X' = X_0 + \text{FAF}'(X - X_0)$$

where:

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$X_0$  = first guess profile on 100 AIRS layers

$X'$  = convolved independent profile on NSurfSup AIRS layers

$X_0, X'$  are NSurfSup  $\times$  1 matrixes

$F$  = NSurfSup  $\times$  N matrix of trapezoids

$A$  = N  $\times$  N averaging kernel matrix

$F' = [F^T F]^{-1} F^T$  = pseudo-inverse of  $F$

Each column of  $F$  represents one of the N trapezoids on the AIRS 100 layer grid, starting from the top trapezoid to the bottom. Comparisons can then be made between the AIRS retrieved 100 layer profile found in the AIRS Level 2 Support Product and the convolved independent profile,  $X'$ .

For the AIRS constituent retrievals ( $H_2O$ ,  $CO$ ,  $CH_4$  and  $O_3$ ) use the logarithm of the profile column density in place of the column density, i.e., use  $\log(\mathbf{XXCDsup})$  instead of  $\mathbf{XXCDsup}$  in this calculation.

In the Level 2 Support file, CO\_trapezoid\_layers gives the layers on which the CO variables are defined. There are a maximum of 9 layers identified, depending upon NSurfSup. They are:

1, 20, 45, 56, 63, 70, 81, 89, 93, 100

but the bottom level index and number of layers varies with surface pressure and nSurfSup. For instance, if nSurfSup < 100 and nSurfSup > 93, then the layers are usually :

1, 20, 45, 56, 63, 70, 81, 89, 93, nSurfSup.

These correspond to pressures:

0.0161, 9.5119, 110.2366, 212.0277, 300.0, 407.4738, 617.5112, 802.3714, 904.8659, PressSup(nSurfSup)

Here is an example assuming that the interpolation hinge points for each trapezoid for nSurfSup = 97. The trapezoids are built piecewise, using linear interpolation in natural logarithm (log to base e) of pressure for pressures between the level boundaries with hinge point values given below. **For CO, the trapezoids are normalized such that the sum across all trapezoids = 1 everywhere except the top and bottom where the sum across all trapezoids = 0.5.**

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**First** column of F is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	9.51190	0.500000	0.500000
2	9.51190	110.237	0.500000	0.000000
3	110.237	212.028	0.000000	0.000000
4	212.028	300.000	0.000000	0.000000
5	300.000	407.474	0.000000	0.000000
6	407.474	617.511	0.000000	0.000000
7	617.511	802.371	0.000000	0.000000
8	802.371	904.866	0.000000	0.000000
9	904.866	1013.95	0.000000	0.000000

**Second** column of F is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	9.51190	0.000000	0.500000
2	9.51190	110.237	0.500000	0.500000
3	110.237	212.028	0.500000	0.000000
4	212.028	300.000	0.000000	0.000000
5	300.000	407.474	0.000000	0.000000
6	407.474	617.511	0.000000	0.000000
7	617.511	802.371	0.000000	0.000000
8	802.371	904.866	0.000000	0.000000
9	904.866	1013.95	0.000000	0.000000



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**Third** column of F is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	9.51190	0.00000	0.00000
2	9.51190	110.237	0.00000	0.500000
3	110.237	212.028	0.500000	0.500000
4	212.028	300.000	0.500000	0.000000
5	300.000	407.474	0.000000	0.000000
6	407.474	617.511	0.000000	0.000000
7	617.511	802.371	0.000000	0.000000
8	802.371	904.866	0.000000	0.000000
9	904.866	1013.95	0.000000	0.000000

**Fourth** column of F is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	9.51190	0.00000	0.00000
2	9.51190	110.237	0.00000	0.00000
3	110.237	212.028	0.00000	0.500000
4	212.028	300.000	0.500000	0.500000
5	300.000	407.474	0.500000	0.000000
6	407.474	617.511	0.000000	0.000000
7	617.511	802.371	0.000000	0.000000
8	802.371	904.866	0.000000	0.000000
9	904.866	1013.95	0.000000	0.000000

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**Fifth** column of F is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	9.51190	0.00000	0.00000
2	9.51190	110.237	0.00000	0.00000
3	110.237	212.028	0.00000	0.00000
4	212.028	300.000	0.00000	0.500000
5	300.000	407.474	0.500000	0.500000
6	407.474	617.511	0.500000	0.00000
7	617.511	802.371	0.00000	0.00000
8	802.371	904.866	0.00000	0.00000
9	904.866	1013.95	0.00000	0.00000

**Sixth** column of F is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	9.51190	0.00000	0.00000
2	9.51190	110.237	0.00000	0.00000
3	110.237	212.028	0.00000	0.00000
4	212.028	300.000	0.00000	0.00000
5	300.000	407.474	0.00000	0.500000
6	407.474	617.511	0.500000	0.500000
7	617.511	802.371	0.500000	0.00000
8	802.371	904.866	0.00000	0.00000
9	904.866	1013.95	0.00000	0.00000

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**Seventh** column of F is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	9.51190	0.00000	0.00000
2	9.51190	110.237	0.00000	0.00000
3	110.237	212.028	0.00000	0.00000
4	212.028	300.000	0.00000	0.00000
5	300.000	407.474	0.00000	0.00000
6	407.474	617.511	0.00000	0.500000
7	617.511	802.371	0.500000	0.500000
8	802.371	904.866	0.500000	0.00000
9	904.866	1013.95	0.00000	0.00000

**Eight** column of F is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	9.51190	0.00000	0.00000
2	9.51190	110.237	0.00000	0.00000
3	110.237	212.028	0.00000	0.00000
4	212.028	300.000	0.00000	0.00000
5	300.000	407.474	0.00000	0.00000
6	407.474	617.511	0.00000	0.00000
7	617.511	802.371	0.00000	0.500000
8	802.371	904.866	0.500000	0.500000
9	904.866	1013.95	0.500000	0.00000

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**Ninth** column of F is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	9.51190	0.00000	0.00000
2	9.51190	110.237	0.00000	0.00000
3	110.237	212.028	0.00000	0.00000
4	212.028	300.000	0.00000	0.00000
5	300.000	407.474	0.00000	0.00000
6	407.474	617.511	0.00000	0.00000
7	617.511	802.371	0.00000	0.00000
8	802.371	904.866	0.00000	0.500000
9	904.866	1013.95	0.500000	0.500000

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### IMPORTANT NOTE:

The first and last trapezoid hinge point values are dependent on retrieval settings. For instance, O3, H2O, and CO all have "halftop/halfbot" settings such that the sum across all trapezoids for the 1st and last trapezoids is 0.5.

The first trapezoid for the temperature retrieval is different than the other retrievals in that it is built **using a value of 1.0 instead of 0.5** at the minimum pressure level boundary point nearest the top of the atmosphere:

The **first** column of F for temperature is calculated using linear interpolation over  $\log_e(\text{pressure})$  between these hinge points :

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	0.714000	<b>1.00000</b>	0.500000
2	0.714000	1.29720	0.500000	0.00000
3	1.29720	2.70090	0.00000	0.00000
4	2.70090	4.07700	0.00000	0.00000
5	4.07700	8.16550	0.00000	0.00000
6	8.16550	16.4318	0.00000	0.00000
7	16.4318	23.4526	0.00000	0.00000
8	23.4526	39.2566	0.00000	0.00000
9	39.2566	56.1260	0.00000	0.00000
10	56.1260	71.5398	0.00000	0.00000
11	71.5398	96.1138	0.00000	0.00000
12	96.1138	125.646	0.00000	0.00000
13	125.646	160.496	0.00000	0.00000
14	160.496	212.028	0.00000	0.00000
15	212.028	272.919	0.00000	0.00000
16	272.919	343.618	0.00000	0.00000
17	343.618	424.470	0.00000	0.00000
18	424.470	496.630	0.00000	0.00000
19	496.630	596.306	0.00000	0.00000
20	596.306	661.192	0.00000	0.00000
21	661.192	753.628	0.00000	0.00000
22	753.628	878.620	0.00000	0.00000
23	878.620	1013.95	0.00000	0.00000

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The nearest to surface (tenth if NSurfSup = 97, ninth if PSurfStd < 777 hPa) trapezoid for the CH4 retrieval is different than the other retrievals in that it is built using a value of **1.0 instead of 0.5** as the maximum pressure level boundary point nearest the surface:

	Min p level boundary	Max p level boundary	F at min p level boundary	F at max p level boundary
1	0.0161000	11.0038	0.00000	0.00000
2	11.0038	103.017	0.00000	0.00000
3	103.017	160.496	0.00000	0.00000
4	160.496	212.028	0.00000	0.00000
5	212.028	272.919	0.00000	0.00000
6	272.919	343.618	0.00000	0.00000
7	343.618	441.882	0.00000	0.00000
8	441.882	575.525	0.00000	0.00000
9	575.525	777.790	0.00000	0.500000
10	777.790	1013.95	0.500000	<b>1.00000</b>

We recommend that the interested user see the paper:

Maddy, E.S. and C.D. Barnet, (2008), Vertical Resolution Estimates in Version 5 of AIRS Operational Retrieval, IEEE TGARS, Vol 46, #8, pp2375-2384.

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### *Temperature Profiles*

The standard product temperature profile, **TAIRStd**, and the support product temperature profile, **TAIRSup**, are both level quantities, i.e. they are the retrieved air temperature at the corresponding pressure level. **TAIRStd** is reported on the **pressStd** levels and **TAIRSup** is reported on the **pressSup** levels. The pressure arrays appear once per granule as attributes rather than being replicated 1350 times as full swath arrays. They are listed for convenience in the two documents:

**V5\_L2\_Standard\_Pressure\_Levels.pdf**

**V5\_L2\_Support\_Pressure\_Levels.pdf**

Both temperature profiles vary linearly between levels, and **TAIRStd** is obtained from **TAIRSup** using linear interpolation with pressure. The surface air temperature, **TSurfAir**, is then obtained from the support product temperature profile, also using linear interpolation with pressure. Recall that **nSurfSup** specification is 1-based. For IDL or C codes, **nSurfSup** in the two formulae below should be replace by **(nSurfSup - 1)**.

Let:

$$f = \frac{PSurfStd - pressSup[nSurfSup]}{pressSup[nSurfSup - 1] - pressSup[nSurfSup]}$$

The surface air temperature at **PSurfStd** is:

$$TSurfAir_{PSurfStd} = f \times TAIRSup[nSurfSup - 1] + (1 - f) \times TAIRSup[nSurfSup]$$

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### Moisture Profiles

All moisture profiles in the standard and support products are layer quantities. Except at the top of the atmosphere, they are the mean for a layer whose bottom boundary is the pressure level at which they are reported and whose top boundary is the pressure level immediately above. See **V5\_L2\_Standard\_Pressure\_Levels.pdf** for a table of the pressure level array, **pressH2O**.

The standard product moisture profile, **H2OMMRStd**, and its associated estimated error, **H2OMMRStdErr**, are both the mean mass mixing ratio in gm/kg\_dry\_air between adjacent **pressH2O** levels. For  $14 > J \geq nSurfStd$ , the value at level **J** is the mean mixing ratio between level **J** and **J+1**. For **J=15**, the value is the mean over the layer bounded by that pressure level (50 mb) and the TOA of the support product (0.005 mb). The mean mixing ratio in the layer bounded by the surface is equal to mixing ratio at **nSurfStd**.

The support product moisture profile, **H2OCDSup**, is the layer amount (molecular column density) in molecules/cm<sup>2</sup> between the defined **pressSupp** levels. For  $2 < J < nSurfSup$ , the value at level **J** is the amount between level **J** and level **J-1**. The value at **J=1** is the layer amount between that pressure level (0.0161 mb) and the TOA, 0.005 mb.

#### VERY IMPORTANT:

For the layer closest to the surface, the pressure that defines the lower boundary is actually **PSurfStd**. This boundary may be somewhat above or just below one of the defined pressure levels of the **pressSupp** array, and it is different from the pressure of the level upon which it is reported, **nSurfSup**. The molecular column density must be scaled in the following manner to arrive at the amount bounded by **pressSupp[nSurfSup-1]** and **PSurfStd**. The values of **H2OCDSup** below **pressSupp[nSurfSup]** are set to zero.

The scaled value of **H2OCDSup** to account for influence of topography is calculated thusly:

$$H2OCDSup_{scaled} = H2OCDSup[nSurfSup] \times \frac{(PSurfStd - pressSupp[nSurfSup-1])}{(pressSupp[nSurfSup] - pressSupp[nSurfSup-1])}$$

Recall again that **nSurfSup** specification is 1-based. For IDL or C codes, **nSurfSup** in the formula above should be replaced by **(nSurfSup - 1)**.

Addition of this scaled near-surface amount to all the other **H2OCDSup** profile elements and conversion of the total to kg/m<sup>2</sup> results in a value matching **totH2OStd**.



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**H2OMMRSat\_liquid** and **H2OMMRSat** both provide profiles of the integrated mass of water vapor in saturated equilibrium between **pressH2O** levels divided by the integrated mass of dry air. **H2OMMRSat\_liquid** assumes equilibrium with liquid water.

**H2OMMRSat** is in equilibrium with the physically correct equilibrium phase: liquid or ice. The physically correct equilibrium phase is ice from the point at which **TAirSup** (100 level profile) falls below 273.15 K; otherwise the equilibrium phase is liquid water. Thus within a layer in which the **TAirSup** crosses 273.15 K, the saturation calculation will shift between saturation over ice and that over liquid water. Near the surface the two saturation profiles are identical, but they will diverge in the case that the temperature profile crosses the threshold. The constituent relationship employed is that of Murphy and Koop (2005).

**Important note:** The V4 saturation mixing ratio was calculated at the temperature of the standard pressure levels using Buck (1981). The calculation took into account the shift from liquid to ice at 273.15 K, but the saturation profile was not an integration over each layer. Instead, it was a level quantity at the standard pressure levels. It could not be directly compared to the observed moisture profile, which was a layer quantity. Doing so would result in absurd estimates of relative humidity, the most benign effect being a dry bias.

Buck, A. L. (1981), New equations for computing vapor pressure and enhancement factor, J. Appl. Meteorol., 20, 1527-1532.

Murphy, D. M. and T. Koop (2005), Review of the vapour pressures of ice and supercooled water for atmospheric applications, Quart. J. Royal Met. Soc, 608 Part B, 1539-1565.

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### ***Ozone Profiles***

The standard product and support product ozone profiles are all layer quantities. Except at the top of the atmosphere, they are the mean for a layer whose bottom boundary is the pressure level at which they are reported and whose top boundary is the pressure level immediately above.

The standard product ozone profile, **O3VMRStd**, and its associated estimated error, **O3VMRStdErr**, are the mean volume mixing ratio in molecules/molecules\_dry\_air between **pressStd** levels. For  $28 > J \geq nSurfStd$ , the value at level **J** is the mean mixing ratio between level **J** and **J+1**. For **J=28**, the value is the mean over the layer bounded by that pressure level (0.1 mb) and the TOA of the support product (0.005 mb). The mean mixing ratio in the layer bounded by the surface is equal to mixing ratio at **nSurfStd**. **O3VMRStd** and **O3VMRStdErr** may be converted to parts per billion by volume (ppbv) simply by multiplying by  $10^9$ .

The support product ozone profile, **O3CDSup**, is the layer amount (molecular column density) in molecules/cm<sup>2</sup> between **pressSupp** levels. For  $2 < J < nSurfSup$ , the value at level **J** is the amount between level **J** and level **J-1**. The value at **J=1** is the layer amount between that pressure level (0.0161 mb) and the TOA, 0.005 mb.

#### **VERY IMPORTANT:**

For the layer closest to the surface, the pressure that defines the lower boundary is actually **PSurfStd**. This boundary may be somewhat above or just below one of the defined pressure levels of the **pressSupp** array, and it is different from the pressure of the level upon which it is reported, **nSurfSup**. The molecular column density must be scaled in the same manner as in the above discussion of the moisture profile to arrive at the amount bounded by **pressSupp[nSurfSup-1]** and **PSurfStd**. The values of **O3CDSup** below **pressSupp[nSurfSup]** are set to zero.

### ***Ozone Trapezoidal Profile***

See the discussion in the section, "Trapezoidal Layers", above. Replace XX with O3 in that text.

The AIRS standard O<sub>3</sub> product is a product of the IR stage of the combined IR/MW retrieval. **O3\_VMR\_eff** is the retrieved volume mixing ratio (ratio of number of O<sub>3</sub> molecules to the number of molecules of air in a unit volume) for a layer defined by the faces of the O<sub>3</sub> trapezoidal retrieval function. The boundaries of the faces of these layers are specified in **O3\_trapezoid\_layers**. In V5, there are 9 such layers corresponding to the 9 trapezoidal retrieval functions utilized for O<sub>3</sub>.

## V5 Level 2 Product Levels, Layers and Trapezoids

### ***Carbon Monoxide Trapezoidal Profile***

See the discussion in the section, “Trapezoidal Layers”, above. Replace XX with CO in that text.

The AIRS standard CO product is a product of the IR stage of the combined IR/MW retrieval. **CO\_VMR\_eff** is the retrieved volume mixing ratio (ratio of number of CO molecules to the number of molecules of air in a unit volume) for a layer defined by the faces of the CO trapezoidal retrieval function. The boundaries of the faces of these layers are specified in **CO\_trapezoid\_layers**. In V5, there are 9 such layers corresponding to the 9 trapezoidal retrieval functions utilized for CO.

### ***Methane Trapezoidal Profile***

See the discussion in the section, “Trapezoidal Layers”, above. Replace XX with CH<sub>4</sub> in that text.

The AIRS standard CH<sub>4</sub> product is a product of the IR stage of the combined IR/MW retrieval. **CH<sub>4</sub>\_VMR\_eff** is the retrieved volume mixing ratio (ratio of number of CH<sub>4</sub> molecules to the number of molecules of air in a unit volume) for a layer defined by the faces of the CH<sub>4</sub> trapezoidal retrieval function. The boundaries of the faces of these layers are specified in **CH<sub>4</sub>\_trapezoid\_layers**. In V5, there are 7 such layers corresponding to the 7 trapezoidal retrieval functions utilized for CH<sub>4</sub>.